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Electrophysiological evaluation of peripheral nerve injuries in Maraş earthquake victims

Peripheral nerve injuries in Maraş earthquake

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Abstract

Aim: On February 6, 2023, the province of Maraş province, in southern Turkey, was shaken by two destructive earthquakes measuring 7.7 and 7.6 degrees of the Richter scale, 8 hours apart. In earthquakes, peripheral nerve injuries (PNIs) frequently occur and cause significant long-term disability in surviving patients. This study aimed to analyzes the clinical, demographic, and electromyographic features of PNIs resulting from the Marashş earthquakes.

Material and Methods: The first electrophysiological test results of 130 earthquake victims were recorded. Demographic and clinical characteristics of the patients, electrophysiological features of PNIs detected in each patient, and other accompanying musculoskeletal injuries were recorded.

Results: The frequency of injuries was 98 (75.4%) peripheral nerves, 11 neural plexuses, four cervical radiculopathies, eight cauda equina lesions, three cranial neuropathies, and five entrapment neuropathies. The most frequently injured nerve was the sciatic nerve (46.2%); the second was the ulnar nerve (26.9%), followed by the median (18%) and radial nerves (18%). Combined PNIs were present in 36 (27.7%) patients.

Discussion: PNIs are one of the most frequent injuries in earthquake victims. Prolonged compression, soft tissue injuries, bone fractures, compartment and Crush syndrome, and exposure of extremities to traction during rescueing have been observed as facilitating factors in earthquake-related PNIs.

Keywords

Earthquake, Peripheral Nerve, Injury, Electromyography, Turkey, Maraş, Pazarcık, Elbistan

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Introduction

It is known that more than 500,000 earthquakes occur worldwide every year [1]. Earthquakes cause many casualties and massive damage with their catastrophic impact. In recent years, several destructive earthquakes have occurred in Turkey. The most devastating of these earthquakes occurred on February 6, 2023, in Pazarcık, Maraş Province, in the Southern East of Turkey, with a magnitude of 7.7 on the Richter scale. A second earthquake with a magnitude of 7.6 occurred in Elbistan 8 hours later thanafter the first, destroying the cities of Maraş, Adiyaman, Malatya, Antep, Urfa, Diyarbakir, Adana, Hatay, Kilis, and Osmaniye in Turkey. These earthquakes were felt in over a wide geographic area, including Syria, Lebanon, Cyprus, Iraq, Israel, Jordan, Iran, Egypt, as well as Turkey. About 50,783 people died, and more than 122,000 were injured (available at: www.sbb.gov.tr/logo/2023-kahramanmaras-ve-hatay-depremleri-raporu). Most of the buildings, including many historic buildings, were destroyed, and too many people became hoouseless. In surviving persons, various crush injuries were observed depending on the type and time spent under the debris. Most earthquake-related injuries occur under the rubble of collapsed buildings and falling objects [2]. The most common type of injury in earthquakes is extremity traumas [3]. As a result of these traumas, peripheral nerve injuries (PNIs) are common in earthquake survivors. However, PNIs may be overlooked by clinical or surgical teams in disaster situations as earthquakes because the priority is life-saving. Complex multiple traumas such as deep soft tissue injuries, open wounds, and bone fractures are frequently accompanied by PNIs. Diagnosis and treatment of PNIs may be delayed due to both accompanying injuries and conservative or surgical procedures applied in treating these injuries, such as external fixators or casts for bone fractures or fasciotomies for compartment syndrome. Rehabilitation professionals may be the first to detect PNIs. While PNIs are not life-threatening, they can cause long-term disabilities and affect the surviving persons'the quality of life of survivors [4,5].

Peripheral nerve impairment is usually diagnosed based on clinical findings and electrophysiological testing, which include nerve conduction studies (NCS) and needle electromyography (EMG). Electrophysiologic studies are essential in detecting abnormal nerves in patients with PNIs. These studies help localize the lesion's site, determine the lesion's type and severity, and assist in prognosticationing [6]. Electromyographic applications require special attention in earthquake victims who have experienced severe physical and mental trauma [7]. Published data on earthquake-related PNIs was relatively limited in the current literature [8-11]. Therefore, this study aims to describe our center analysis of PNIs on earthquake victims referred to our electrophysiology laboratory after the Maraş earthquakes in Turkey.

Material and Methods

This retrospective single-center study evaluated 130 patients who had been injured in the Maraş earthquakes and had signs of impaired peripheral nerves or complained of any symptoms regarding neuropathy. The first electrophysiological test results of 130 earthquake victims who underwent clinical examination and were referred to the electrophysiology laboratory in the Department of Physical Medicine and Rehabilitation of Ankara Etlik City Hospital from February 2023 to June 2023 were recorded. The information of patients, including gender, age, the injury location (upper extremity/lower extremity/both upper and lower extremities/spine/facial), side of injury (right/left/bilateral), specific nerve injury, soft-tissue condition at the time of injury, the time spent under the debris (hours), Crush syndrome, accompanied injuries (bone fracture/amputation/compartment syndrome/fasciotomy) were also recorded. Inclusion criteria accepted as were patients with earthquake-related PNIs confirmed by electrophysiological testing. Patients whose electrophysiological test results did no't indicate any nerve injury or the test could not be completed were excluded from the study. Electro-diagnostic studies were performed with a Medelec workstation (Medelec/TECA Synergy -EMG/EP Plinth System T) for each patient. Research protocols were followed by the Declaration of Helsinki, and local ethics committee approval was obtained for the study (decision no: 2023-446, date: 2023-08-09).

Statistical analysis

Statistical Package for Social Science (SPSS) version 20.0 software (IBM Corporation, Chicago, IL) was used for assessing collected data. The Shapiro-Wilks test was used for data distribution analysis. Categorical and continuous variables were represented in percentage, number, and median (min-max). Descriptive statistical methods were used in the evaluation of the data.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

Characteristics of subjects

The medical files of 145 patients who experienced the Maraş earthquakes and were referred to the electrophysiology laboratory were evaluated retrospectively. Since six patients' electrophysiological test results did no't indicate any nerve injury, nine were excluded from the study because the test could not be completed. One hundred thirty patients met the enrollment criteria and were included in this study. Among these 130 patients, 71 (54.6%) were female, and 59 (45.4%) were male. The mean age of the patients was 27 (1-72) years, and the age distribution of the patients was as follows: 46 patients aged 1-20 years (35.4%), 48 patients aged 21-40 years (36.9%), 34 patients aged 41-60 years (26.2%), three patients aged 61-80 years (2.3%), as seen in Table 1.

Electro-diagnostic test results

In this study, 130 patients with PNIs were evaluated for their injuries. The mean time between the date of injury and electrophysiological testing was 64 (15-162) days. The frequency of injuries were as follows: 97 (74.6%) peripheral nerves, 18 neural plexuses (13.8%), seven cervical radiculopathies (5.4%), eleven cauda equina lesions (8.4%), three cranial neuropathies (2.3%), and five entrapment neuropathies (3.8%), as seen in Figure 1. PNIs were detected in the upper extremities in %30 of patients, in the lower extremities in 47.7%, and in both upper and lower extremities in %11.5 of patients. There wasn't ano significant lateralization difference on the injury side (36.9%

Table 1. Demographic and earthquake-related injury features

Variables, med (min-max), n (%)		Total (n=130)
Age (years)		27 (1-72)
1-20		46 (35,4)
21-40		48 (36,9)
41-60		34 (26,2)
61-80		3 (2.3)
Gender	Female	71 (54,6)
	Male	59 (45,4)
Time spent under the debris (hours)		6 (2-144)
The time since injury (days)		64 (15-162)
Nerve injury side	Right	48 (36,9)
	Left	54 (41,5)
	Bilateral	28 (21,5)
Nerve injury location	Upper extremity	39 (30)
	Lower extremity	62 (47,7)
	Both upper and lower extremities	15 (11,5)
	Facial	3 (2,3)
	Spine	11 (8,4)
Other injuries	Crush syndrome	45 (34,6)
	Compartment syndrome and fasciotomies	36 (27,7)
	Bone fractures	34 (26,2)
	Extremity amputation	24 (18,5)
	Head injury	2 (1,6)

Values are median (minimum-maximum) or percentage (n,%)

Table 2. Electro-diagnostic test results

Variables, n (%)	Total (n=130)
Entrapment neuropathy	5 (3,8)
Peripheral nerve injury	97 (74,6)
Ulnar	35 (26,9)
Median	24 (18,5)
Radial	24 (18,5)
Axiller	2 (1,5)
Suprascapular	2 (1,5)
Musculocutaneous	4 (3,1)
Superior gluteal	1 (0,8)
Femoral	8 (6,2)
Sciatic	60 (46,2)
Peroneal	13 (10)
Combined peripheral nerve injury	36 (27,7)
Neural plexus	16 (12,3)
Brachial plexus	7 (5,4)
Lumbosacral plexus	4 (3,1)
Radiculopathy	18 (13,8)
Cervical	7 (5,4)
Lumbar	11 (8,4)
Cranial neuropathy	3 (2,3)
Axonal damage	125 (96,2)
Severity of nerve injury	
Mild	6 (4,6)
Mild to moderate	7 (5,4)
Moderate	23 (17,7)
Moderate to severe	10 (7,7)
Severe	66 (50,8)
Total axonal degeneration	18 (13,8)

Values are percentage (n,%)

right, 41.5% left, 21.5% bilateral). The most frequently injured nerve was the sciatic nerve (46.2%), the second was the ulnar nerve (26.9%), followed by the median (18.5%) and radial nerves (18.5%), and the less frequent nerves were as follows: common peroneal nerve in 13 (10%) patients, femoral nerve in 8 (6.2%) patients, musculocutaneous in 4 (3%) patients, the axillary nerve was in 2 (1.5%) patients, suprascapular nerve was in 2 (1.5%) patients and superior gluteal nerve in just 1 (0.8%) patient. 11 Eleven (8.5%) patients had brachial plexus and 7 (5.4%) had lumbosacral plexus injuries. Combined PNIs were present in 36 (27.7%) patients. Nerve injury characteristics and distribution are shown seen in Figure 2 and Table 2.

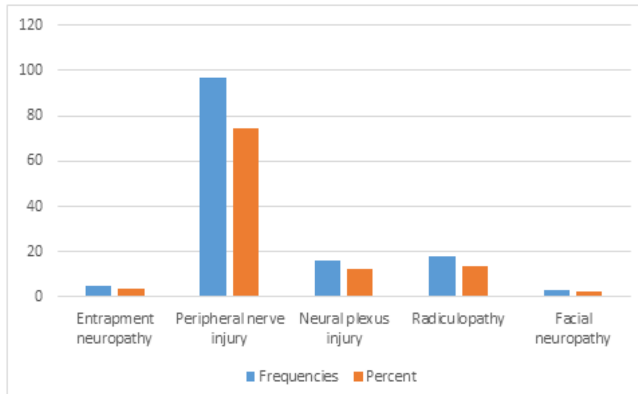

Figure 1. Electro-diagnostic test results

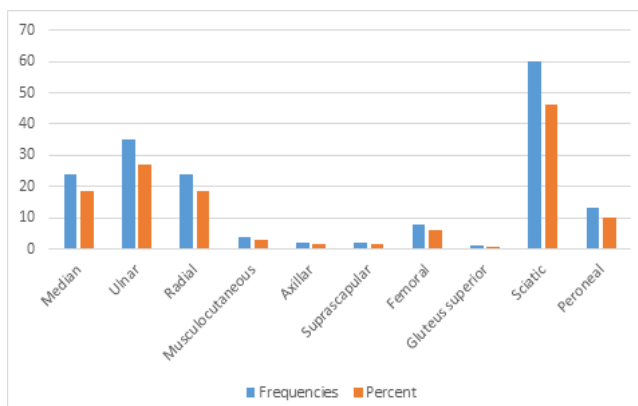

Figure 2. Distribution of peripheral nerve injuries

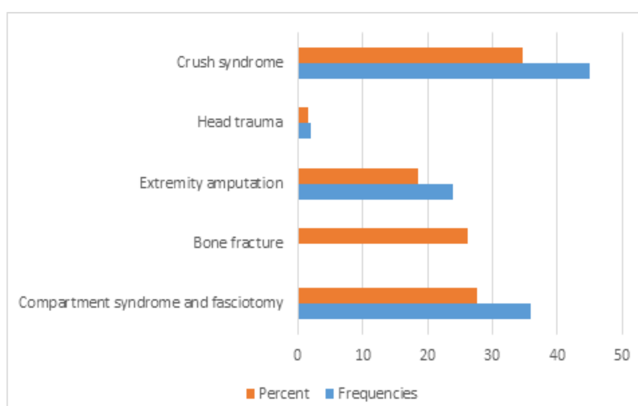

Figure 3. Other injuries accompanying PNIs

Other injuries accompanying PNIs

All patients experienced soft tissue compression. Fourty-five (34.6%) patients had Crush syndrome. Thirty-six (27.7%) patients underwent fasciotomy due to compartment syndrome. There were accompanying bone fractures in 34 (26.2%) patients, extremity amputations in 24 (18.5%), and head trauma in 2 (1.6%) patients, as shown seen in Figure 3 and Table 1.

Discussion

This study evaluated the clinical, demographic, and EMG findings of 130 patients referred to our electrophysiology laboratory with the preliminary diagnosis of PNI after the Pazarcık and Elbistan earthquakes in Turkey. PNIs were detected in the upper extremities in %30, in the lower extremities in 47.7%, and in both the upper and lower extremities in %11.5 of the patients. The sciatic nerve was the most frequently injured. The ulnar nerve was the most common injury in the upper extremity, followed by median and radial nerves. The male and female rates were almost similar (54.6 female/45.4 male). They were predominantly young, and the median age was 27. There wasn't a significant lateralization difference on the injury side (36.9% right, 41.5% left, 21.5% bilateral). Combined nerve injury was observed in 36 (27.7%) patients.

PNIs are a heterogeneous and diverse group of disease that develops due to various causes [12]. The most common reasons are falls, home accidents, motor vehicle accidents, industrial accidents, and penetrating traumas [13]. Injury mechanisms in PNIs usually include traction, contusion, or laceration caused by penetrating trauma [11]. In a study by Noble et al. performed in a trauma center to investigate the prevalence of multiple PNIs, the researchers reported that the radial nerve is the most common PNI in upper limbs, followed by the median and ulnar nerves, and the sciatic nerve was the most common PNI in lower limbs, followed by peroneal and tibial nerves [14]. Earthquake-related nerve injuries are caused mainly by collapsed buildings or flying debris such as stones, furniture, bricks, or other falling objects. Crushing also provokes injuries to the body and extremities due to prolonged pressure [11,15]. Current published data on earthquake-related PNIs have been was relatively limited [8-10,16]. There have been were studies on the Hanshin-Awaji earthquake in Japan [10], the Wunchuan earthquake in China [4,17], the Bam earthquake in Iran [16], and the Marmara earthquake in Turkey [7,9]. Our study observed that the most common injury was in the lower extremities, with a rate of 47.7% of the patients. Uzun et al. reported that the lower extremities were the most frequently injured area, with a rate of 47.5% in the 1999 Marmara earthquake in Turkey [7]. Similar to our study, previous studies have shown indicated that the highest incidence of PNIs is in the lower limbs [18,19]. In our research, the most frequently injured peripheral nerve was the sciatic. The ulnar nerve was the most commonly injured in the upper extremity, followed by the median and radial nerves. Ahrari et al. investigated the prevalence and distribution of PNIs that developed after the Bam earthquake in Iran in 2003; they reported that the most frequently damaged peripheral nerve was the sciatic nerve, and the radial nerve was the second one [16]. Injuries were related to the duration of compression, body position under the debris, and tension on the nerve. He et al. supported that the sciatic nerve is more vulnerable to damage in flexed hip and knee positions [8].

Direct damage to nerve fibers, ischemia-reperfusion injuries, or compartment syndrome due to primary compression and secondary soft tissue swelling can lead to earthquake-related PNIs [17]. Crushing can cause necrosis of muscles, compartment syndrome of the affected extremities, pain, sensation disturbance, and muscle weakness. Peripheral nerves are affected very rapidly by changes in the oxygen pressure of the nervous tissues. As a result, peripheral nerve function may be lost within 30 to 90 minutes following the initial ischemia [20]. In earthquakes, nerve and muscle ischemia can worsen nerve conduction, endoneurial ischemia, and structural damage at the last stage. The time spent under the debris is directly proportional to the degree of nerve damage. Numerous cases have shown that earthquake-related PNIs are induced mainly by prolonged compression on the degenerated nerve side [10]. Injury can occur on any nerve side and may be due to direct nerve compression by a foreign object or laceration of the nerve fibers by a broken bone. Crushing and compartment syndrome are other associated factors with earthquake-related PNIs [8]. Acute force exposure or traction of nerves due to extremity stretching during rescuing is also associated with PNIs [16]. Combined nerve injuries are frequently observed in earthquakes [5]. In our study, almost one-third of the cases had combined nerve injuries.

Electrophysiological studies are crucial to demonstrate abnormal nerves in patients with PNIs. NCS and needle EMG are often used in electromyographic protocols. The primary purpose of electrophysiological studies is to localize the lesion, determine the type and severity of injury, and predict prognosis [6,21]. The most widely used classification for PNIs is Seddon and Sunderland [22,23]. The Seddon classification divides PNIs into neuropraxia, axonotmesis, and neurotmesis. Neurapraxia is a mild injury with impaired motor and sensory functions due to temporary nerve conduction blockage due to myelin sheath loss without axonal damage. Axonotmesis is a nerve damage in which axon damage occurs, but most connective tissue elements, such as the endoneurium, perineurium, and epineurium, are still wholly or partially intact [22]. This injury form is common in crushing and traction injuries [24]. Neurotmesis is the most severe type of nerve damage in which the axon, myelin sheath, and all connective tissue elements are damaged. The Sunderland classification divided PNIs into five groups. First-degree injury matches neuropraxia according to Seddon's classification. Second-, third-, and fourth-degree injuries refer to disruption of the axon (Seddon axonotmesis) with the endoneurium, perineurium, and epineurium, respectively. Fifth-degree injury matches neurotmesis according to Seddon's classification. Sixth-degree injury is a combined lesion with varying degrees of axon loss and conduction block. This type of injury is estimated to be the most common form of nerve damage [23]. The severity of PNIs correlates positively with the duration of compression [24]. In this study, patients with severe peripheral nerve damage, reduced interference, or total axonal degeneration in recruitment pattern on needle EMG constituted 84 (74.6%) of the patients with PNIs. This result may indicate a poor recovery expectation for these cases. In addition, considering that 74.3% of our patients are were aged 40 and under, this result may be associated with the need for rehabilitation for a more extended period and the loss of workforce in the future. All patients experienced soft tissue compression from crush injuries ranging from a few hours to 6 days. Because the Pazarcık earthquake happened at 4.17 a.m. when most people were asleep in their homes, too many people were trapped under the rubble of the building blocks. The significant injuries were bone fractures, head injury, compartment syndrome in extremities, crush syndrome, and PNIs. Compared to PNIs that occur daily, earthquake-related PNIs include combined nerve injuries and nerve compression by scar tissue, which often develops due to accompanying soft tissue traumas [11].

Limitation

This study has a few limitations. First, the number of patients is limited as there isit was a single-center study. Second, this study includes only the first electrophysiological test results. There is no information about the follow-up conditions of nerve lesions.

Conclusion

Many earthquake victims with injuries face some physical and mental disorders, which will probably change the rest of their lives. PNIs are one of the most frequent injuries, which may cause temporary or lifelong disabilities in earthquake victims. Prolonged compression, closed or open soft tissue injuries, bone fractures, compartment and Crush syndrome, and exposure of extremities to traction during rescuing have been observed as facilitating factors in earthquake-related PNIs. As physicians working in the EMG laboratory of a tertiary hospital where earthquake victims are widely hospitalized, we believe that documenting the data obtained from such an experience for similar situations will be guiding.

Scientific Responsibility Statement
The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and Human Rights Statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Conflict of Interest
The authors declare that there is no conflict of interest.

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